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ABSTRACT

Teams-Games-Tournament (TGT) is an instructional mode consisting of three components: 1) teams, involving assignment of students in a classroom to a series of four/five-member teams; 2) games, consisting of a series of instructional or learning games, and 3) tournament, consisting of weekly game-playing sessions in which each student competes with two other students of comparable achievement level representing other student teams. This report describes the developmental effort which resulted in the production of TGT materials and teacher manuals for junior high school level biological and physical sciences, including the preparation of a learning objectives blueprint; construction of student worksheets and instructional games based on the learning objectives; formative evaluation of the materials; and material revision and dissemination. Appendices include the complete TGT life and physical science learning objectives and evaluation instruments and instructions for their use. (Author/JN)

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Technical Report

Developing Science Curriculum Units Using the Teams-Games-Tournaments (TGT) Instructional Process

John H. Hollifield
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Teams-Games-Tournament (TGT) is an innovative instructional mode developed at the Center for Social Organization of Schools through five years of classroom experiments. The process is now being used in mathematics, language arts, social studies and other classrooms. The objective of this project was to develop TGT curriculum materials for junior high school science. This report describes the developmental effort which resulted in the production of TGT materials and teacher manuals for Life Science and Physical Science.

The TGT Process.

TGT represents a comprehensive change in the reward and task structure which surround a student in the classroom. The change in reward structure involves reinforcing students at the level of small groups, rather than at the individual student level. Task structure changes are created by having each student perform in a small group setting, rather than in an isolated, individual setting. Through the use of small groups, students have a greater chance of being successful. The small group structure also leads students to reinforce each other for successful performance, promoting greater learning. The particular combination of structural changes used by TGT follows directly from research in both social psychology and instructional gaming.

TGT has three components: teams, games, and tournaments. The team component involves assigning students in a classroom to a series of four- or five-member teams. The students are assigned to create maximal heterogeneity within each team (in such dimensions as student academic achievement, race, and sex) and homogeneity across teams. Team membership remains intact

over time; within-team interaction and cohesion is fostered by frequently held team work sessions and by assigning teammates to adjacent seats. During team work sessions, the team members work together on worksheets that focus on specific learning objectives. The games component consists of a series of instructional or learning games. The tournament component consists of a series of instructional or learning games. The tournament component consists of weekly (or even twice weekly) game-playing sessions, typically lasting 30 to 50 minutes, in which each student competes with two other students of comparable achievement level representing other student teams. The instructional games used in the tournaments cover the same and related material that the students worked together on in their teams. At the end of each tournament a "top scorer," "middle scorer," and "low scorer" are declared for each three-person tournament table. The individual student scores are converted to team scores. The team scores are ranked and winning teams are declared. Public feedback concerning both individual and team performance is provided periodically. After each day's play, students are routinely reassigned to different tournament tables, based on recent performance, to insure that all students retain a good chance of winning and thus remain motivated.

TGT Effects on Students

TGT has been found to significantly increase student achievement in math, vocabulary, and reading skills; student attitudes toward the class; cross-racial cooperation and understanding; cross-sex cooperation and understanding; and peer tutoring.

TGT has shown strong effects in raising the achievement scores of low achievers. It has also shown effects in raising the scores of high achievers.

In general, it has succeeded across race, sex, and ability levels.

The research studies which found these effects are summarized by DeVries and Slavin (1978) and DeVries, Edwards and Slavin (1978). The studies were conducted in elementary and junior high language arts and mathematics, and in each study the TGT class was compared with a control class receiving traditional instruction.

Developmental Activities

The general approach to developing junior high school science materials for TGT was to follow a model that had been successfully used to produce TGT curriculum units for elementary and junior high math and language arts (Hollifield, 1978). The main features of this model are (1) prepare a blueprint of learning objectives for the curirculum unit, (2) construct, using teacher input and skills, the student worksheets and instructional games based on the learning objectives, (3) formatively evaluate the materials in ongoing classrooms, (4) revise the materials based on pilot test results, (5) disseminate through commercial publication.

Before proceeding with the development, the project established an advisory committee to provide guidance, content expertise, and community input. The committee was scheduled to meet at intervals which coincided with the project activities, in order to provide evaluation and redirection upon completion of each activity. The committee included:

Dr. James Latham, Director, Science Curriculum, Maryland State Department of Education

Dr. Constance Tate, Coordinator of Science, Baltimore City Public Schools

Nanette Williams, 7th grade science teacher, Bel Air Middle School, Harford County, Maryland

Charles DeBolt, lifetime PTA member, Dundalk, Maryland.

Activity 1: Prepare a learning objectives blueprint

Through discussions with consultants, the advisory board and various science specialists the following point of view was developed and clarified: The chief asset of the program lies in the cooperative social process inherent in TGT and the accompanying motivation to assimilate new information. Thus, it follows that TGT Science would be a supplementary program. Using this point of view as a basic reference, we then needed to determine: (A) What are the common 7th and 8th grade units on a national scale? (B) What are the most commonly used texts? (C) Which topics and objectives are addressed most commonly by texts and curriculum guides? and (D) Which objectives relating to each topic best lend themselves to TGT?

A. Determine common 7th and 8th grade courses of study in science.

State textbook adoption lists, ERIC reports, state curriculum guides, and periodicals were reviewed and discussions with teachers and science specialists were held to help make some determination as to what were the broad areas of content in junior high school science. Three courses of study--life science, physical science, and earth science--emerged. It became clear that life science indisputably is the main course of instruction nationwide in seventh grade science. However, it was not equally clear whether physical or earth science was the 8th grade unit. Almost all states did use one or the other, and usually had these two areas flip-flopped as 8th and/or 9th grade science. Physical science did seem to be slightly more predominant, so it was chosen for development over earth science. Subsequently, we altered our objective of developing 7th and 8th grade science units to accommodate what we felt was a more sensible position: We would de-

velop life science and physical science TGT materials, and schools could use them in 7th, 8th, and/or 9th grade according to the individual course of study prescribed in each school or school system.

B. Determine the most commonly used texts.

We felt that since our program was to be a supplementary one we should be supplementing primarily textbooks, because most science programs in schools are based on textbook usage. It became important then to find out which textbooks were most commonly used. Letters were written to all state science supervisors for textbook adoption and recommendation lists. Many states and supervisors are reluctant to make such recommendations, not wanting to usurp the autonomy of local districts. However, nineteen states replied. Below, the frequency of the most popular texts are shown in life and physical science.

Life Science

14/19 Charles B. Merrill, Focus on Life Science

14/19 Prentice Hall, Ideas and Investigations in Science: Life Science

14/19 Rand McNally, Interaction of Man and the Biosphere

13/19 Houghton-Mifflin, Spaceship Earth: Life Science

12/19 Allyn and Bacon, Exploring Life Science

11/19 Ginn, Life Science: A Problem Solving Approach

10/19 Holt, Rinehart, Winston, Modern Life Science

10/19 Silver Burdett, The Natural World

9/19 Lippincott, Life Science: A Search for Understanding

7/19 Harcourt, Brace, Janovich, Life: Its Forms and Changes

7/19 Laidlaw, Biological Science: Investigating Man's Environment

7/19 McGraw-Hill, Challenges to Science: Life Science

Physical Science

13/19 Charles B. Merrill, Focus on Physical Science

12/19 Rand McNally, Interaction of Matter and Energy

12/19 Silver Burdett, The Natural World

11/19 Holt, Rinehart, Winston, Modern Physical Science

10/19 Houghton, Mifflin, Spaceship Earth: Physical Science

10/19 L Lippincott, Physical Science: A Search for Understanding

10/19 Prentice-Hall, Introductory Physical Science

9/19 Prentice-Hall, Ideas and Investigations in Science

7/19 Ginn, Physical Science: A Problem Solving Approach

7/19 Allyn and Bacon, Exploring Physical Science

7/19 Harcourt, Brace, Javonovich, Matter: Its Forms and Changes

C. Determine topics and objectives most commonly addressed.

To determine the most common life and physical science topics and objectives, we conducted a thorough content analysis of the texts listed above, curriculum development projects of local districts, and objectives generating projects of state departments. We relied heavily on Oregon's K-12 Course Goals in Biological Science, which contains by far the most complete science taxonomy of any we encountered. We used the Oregon taxonomy as a template as we charted the topics covered in various texts. Finally, we merged all lists of objectives in order to work only with those that were included in all sources, reasoning that these objectives covered the really basic content of life and physical science common to almost all schools.

D. Select objectives to be covered by TGT Science.

From the objectives generated through the above process, we needed to apply one more selection cirterion--the translation of the objective into

behavioral terms that could be measured by student answers to specific knowledge items. This step was accomplished with the actual writing of the behavioral objectives. Those that could not be expressed in measurable terms were excluded. Appendix A contains a listing of objectives for Life and Physical Science.

It should be stressed that the process of identifying appropriate units and objectives for TGT life and physical science promoted lively discussion among the authors, the project consultants, and the project advisory committee. A basic point of contention throughout this process, and one that still remains, was the emphasis of the objectives and, subsequently, the materials, on knowledge outcomes. This issue is addressed more fully in this report in the discussion of materials revision.

Activity 2: Construct student worksheets and instructional games based on the learning objectives

The construction of TGT worksheets and gamesheets consists of writing approximately 30 short-answer or multiple-choice items that require knowledge of the specified learning objectives. Most of the item-writing was accomplished over a summer by two science teachers working full-time at the task. The teachers were provided with the list of objectives and extensive reference materials, including the textbooks identified previously. They were also provided with item-writing instructions based on specific criteria for writing effective test items (Gronlund, 1976; Hambleton, 1980).

A weekly review of work-in-progress was conducted to resolve questions, review items, and provide guidance and clarification.

Activity 3: Formatively evaluate the materials

Two distinct activities were required for materials evaluation: first, the selection and training of teachers to use the materials; second, the

actual formative evaluation conducted on the materials which were used.

Teacher participants were selected by explaining the project to science supervisors and their staffs in Baltimore City and surrounding counties (Harford, Frederick, Howard, and Carroll), each of which is a large, autonomous school district. The science supervisors recruited teacher volunteers to take part in the classroom use of the TGT science materials. Each group of teachers in each district received a 3-hour training session in the use of TGT. Table 1 outlines the school districts, schools, and teachers who participated. All teachers agreed to select the material they wanted to use and to employ the TGT process in their science classrooms over an 8-10 week period in the fall of 1978 and over another 8-10 week period in the spring of 1979. This amount of classroom usage was designed to give teachers the opportunity to use the majority of the materials--that is, most of the materials were used at some point by one or more of the teachers. The project provided teachers with classroom copies of all materials that they selected.

Sources of Formative Evaluation Data

The data on which our formative evaluation of the TGT materials and process was based are derived from a variety of sources.

1. Expert review of materials--The science advisor for the project, Dr. Audrey Champagne, provided a critique of topics and the conceptual approach as well as a page-by-page critique of the objectives and materials. Dr. Champagne and Dr. David DeVries, the project's TGT consultant, provided project consultation and suggestions at two consultant meetings per year. The Project Advisory Committee provided critiques of the objectives and materials, and suggestions for classroom implementation and use. Other

Table 1

Teacher Participants in NSF/TGT Science Material Evaluation

Baltimore City

1. Northern Parkway Junior High School

   Rosa True - Life Science
   Brian Corbin - Physical Science

2. Francis Scott Key Junior High School

   Virginia Ives - Life Science
   Dorothy Diggs - Physical Science

3. Garrison Junior High School

   Elizabeth Paige - Life Science
   Esteen Frazier - Physical Science

Howard County

1. Patapsco Middle School

   Leora Caporaletti - Life Science
   Robert Siskind - Physical Science

Frederick County

1. West Frederick Junior High School

   David Rowe - Physical Science
   Mary Queen - Life Science

2. Middletown Middle School

   Tim Rohr - Physical Science
   Gordie Thorpe - Life Science
   Avadna Coghill - 6th grade science (SCIS)

Harford County

1. Aberbeen Middle School

   Don Cunningham - Life Science
   Martha Richardson - Life Science
   Steve Beam - Life Science
   John Scott - Physical Science
   Jim McClennahan - Physical Science
   Mindy Kelley - Physical Science
   David Barczak - General Science (Learning Disabilities)

expert reviews of the complete set of materials were conducted by science educators and other classroom teachers. These reviews included critiques of items as well as objectives.

2. Teacher selection of materials--We allowed teachers to select materials they wished to use, rather than assigning usage. Analysis of the materials selected revealed which materials were most relevant to teacher needs and allowed us to examine the appropriateness of our objectives blueprint. This also provided information on teachers' curricula.

3. Classroom observations--Trained personnel observed in all schools during team practice periods and tournament periods. In both periods, an item observation checklist was checked off as students either practiced the items or played in the tournament. These checklists were analyzed to identify item difficulty level and ambiguities, suggesting needed revisions.

During team practice periods, observers also conducted a general observation describing the classroom activity as a whole, and a specific team practice observation focusing on the activities of one team. A similar general classroom observation and specific tournament table observation was conducted during tournament periods. The objective data provided contributed to examining specific item difficulty, the degree of implementation of the TGT process, and the process variables such as peer tutoring and on-task behavior that occur during the team practice and tournament periods. Subjective data were also collected through a comments section on each form.

4. Teacher interviews--Each teacher involved in the evaluation participated in a 1/2 hour tape-recorded interview conducted by the observer in the school. The interview was unstructured, with teachers directed to voice their opinions and suggestions regarding their use of the TGT science materials.

The interviewer, however, specified and clarified various topics, such as class discipline and curriculum integration, if they were not covered in the teacher's unstructured response.

5. Teacher notebooks--Each participating teacher was provided with a critique notebook containing a full set of the materials being used by that teacher. The teachers critiqued the materials as they used them, with specific encouragement to be critical of the objectives and the items and to mark their criticisms and comments directly on the materials in the notebook.

Appendix B contains copies of observation instruments, instructions for conducting teacher interviews, and instructions to teachers on how to use their critique notebooks.

Analyses of Data

1. Content

The analyses of content are considered most important to this project and are based on the use of all data sources to answer the following questions: (a) Are the learning objectives identified those that are important to the teaching and learning of life and physical science? (b) Are the worksheet/gamesheet items for each objective relevant for that objective? (c) Are the worksheet/gamesheet items accurate and scientifically important? (d) Are the items at the appropriate level of difficulty?

(a) Importance of learning objectives. Review by science experts and teacher input indicated that the learning objectives of the life and physical science curricula were for the most part appropriate and important knowledge objectives. There were differences of opinion, however. Specifically, teachers were generally satisfied and pleased with the objectives and

their fit with the school curricula, as indicated by their selection, critiques, and interviews; however, science expert reviews expressed concern with instances of triviality and concern with the emphasis on knowledge and application objectives as opposed to objectives that would require more student synthesis and evaluation.

(b) Relevance of worksheet/gamesheet items to objectives. Expert review and teacher critiques indicated few problems with relevance of items to objectives. Suggestions were made for adding items in some cases.

(c) Accuracy and scientific importance of items. Analyses indicated that the worksheet/gamesheet items needed careful revision in regard to accuracy of items and scientific importance. Expert review, teacher critique, and classroom observation data indicated the specific revisions to be made.

(d) Level of difficulty. The difficulty level of the materials as a whole, as indicated by expert review and teacher critique, was judged as above average. Within this judgment, there were instances of worksheet/gamesheets that were very easy and others that were very difficult, with the degree of difficulty often dependent upon the simplicity or complexity of the learning objective involved.

The "above-average difficulty" judgment of the materials was based on comparisons with what knowledge and how much knowledge students generally are expected to acquire in science classes through traditional instructional processes. Previous research results, and observations of TGT use in science, however, indicated that students could handle a higher difficulty level of knowledge when instructed through TGT--thus an above-average difficulty level was not considered inappropriate for the TGT science worksheets and gamesheets. This efficacy of the TGT instructional process, however, had impli-

cations for materials revision in regard to scientific and instructional importance of the objectives and the items--because TGT is a very effective method of instruction for knowledge objectives, extreme care had to be taken to insure the importance of the material being taught.

2. Teacher Implementation

Teacher implementation of the TGT process in science was examined through selection of materials, classroom observation, and teacher interviews. Implementation was analyzed in terms of correct use of the process, integration with the science curriculum, and teacher attitudes toward their implementation.

Use of the TGT process. All teachers participating in the project attended a training workshop in TGT use and were provided with a teacher's manual that gave step-by-step instructions for implementing TGT. Classroom observations indicated that the implementation of the process--forming teams, team practice, tournament assignment, tournament play, and feedback to students--proceeded with few difficulties. In interviews, teachers noted the problem caused by student absences and by administrative interruptions of their classroom teaching time. Some minor technical problems were noted in the mechanics of game play and in scoring procedures. Essentially, implementation of the mechanics of the process was easily accomplished by all teachers.

Integration with the Science Curriculum. Teacher selections of materials and teacher interviews showed that the TGT objectives and materials fit well with the science curricula being used by teachers. Some materials were heavily selected, indicating a very good fit; some were selected lightly but this was mainly because of the timing of the use of TGT in the school year.

Classroom observation and teacher interviews revealed a basic problem of implementation that required resolution. The purpose of TGT instruction is to provide a supplementary method to increase learning of basic information and concepts. At the most, it should take two periods per week in the classroom, and the remaining periods should be devoted to methods of instruction at the teacher's discretion. The information provided in the remaining periods may or may not focus on the specific TGT learning objective, depending upon the need and the teacher's emphasis. If the focus is on the specific objective, the instruction should vary and should include experimental lab work, hands-on manipulation, audio-visual presentations, and so on.

Teachers evidenced some difficulty with their integration, bringing out the need for an instructional manual that would provide specific help and suggestions. Many teachers, on the other hand, suggested unique ways to integrate the use of TGT and the materials into their curricula.

Teacher attitudes. Teacher interviews show predominantly positive reactions to the TGT focus and its implementation in the classroom. Initial concerns about teacher time involved in preparation, scoring, and providing stduent feedback were not a problem. Noise level, another initial concern, was mentioned by most teachers, but most viewed the high noise level as "good noise"--students were on-task verbally, and were excited and enthusiastic.

3. Student Attitudes and Achievement

Classroom observation and teacher interviews documented very positive student attitudes toward the use of TGT in their science classrooms; almost all teachers specifically cited student enthusiasm as a major benefit.

Teacher judgments of student achievement indicated that increased learning of basic knowledge and concepts was a strong point of the process.

Some concerns in the analyses included (a) problems of low-achieving students with high-difficulty level materials, resulting in decreased effort, (b) problems of high-achieving students with low-difficulty level materials, resulting in boredom and off-task behavior, and (c) problems with gamesheets that were too similar to the worksheets that students studied and were therefore too easy for most students during the tournament.

Activity 4: Revise the Materials

Revision of the learning objectives and of the TGT curriculum worksheets and gamesheets was conducted based on the results of the formative evaluation. Also, the evaluation highlighted the need for a teacher's manual that concentrated on helping teachers integrate the materials into their curricula and on helping teachers determine what their own proper usage of TGT Science would require. It was very necessary that this manual expound on the philosophy of TGT usage. The following "purpose" statement was written to be included as the first section of the manual:

> TGT should be used in the science classroom in accordance with its strengths--the learning and reinforcement of basic knowledge that will provide a base for further learning and experiences.
>
> Science classrooms provide students with opportunities for meaningful experiences, which should in turn lead to further inquiry. However, students need a stable knowledge base or cognitive structure within their experience in order to proceed with manipulation and application of their learning. This basic philosophy of use of TGT, when applied to the physical science curriculum, has important implications. The materials focus on what TGT does best--the learning of basic skills, information and concepts.
>
> For example, the facile use of laboratory equipment is an important feature in science classrooms, but the basic knowledge re-

quired before facility--identification of equipment and knowledge of the functions of the equipment--can be taught and reinforced through TGT. Similarly, before students can analyze and synthesize chemical formulae, they must first learn chemical symbols and their meanings.

Another good example is vocabulary. Before vocabulary can be facilely applied, a basic level of knowledge of definitions must be assured and strengthened. Before nuances of meaning can be effectively dealt with, the student must acquire a definition that provides the base for the nuances. Vocabulary drawn from experience and reinforced through TGT will provide such a base.

There is no argument that the primary purpose of middle school-junior high school science programs must be to enable students to experience their world and develop the inquiry and investigative skills that they need to examine and understand that world. This purpose can be greatly facilitated, however, when students are able to develop a base of knowledge from which to launch their inquiry and investigation. The purpose of TGT science is to allow students to build that knowledge base successfully, especially students who may traditionally have had difficulty in achieving academic success.

The TGT Physical Science Teacher's Manual and the TGT Life Science Teacher's Manual are contained in Appendix C.

Revision of objectives. The original listing of objectives in Life Science contained 50 objectives; the Physical Science contained 45 objectives. These were trimmed to 47 and 42, respectively, with some objectives being rewritten, some expanded, and others dropped completely. These changes, in light of the overall volume of material, were not major.

Physical Science Units were reorganized in a minor way to include measurement as a separate unit. Life Science Units were reorganized to include General Equipment and Careers as separate units.

Many objectives were rewritten (edited) to enhance clarity and specificity without changing the intent of the objective. In essence, the TGT materials effectively cover the basic body of information presented in Life and Physical Science classrooms throughout the nation.

Revision of materials. The major revisions to the TGT materials (worksheets and gamesheets) included increasing the difficulty level of some, decreasing the difficulty level of others, revision and correction of inaccurate items, and decreasing the similarity between worksheet and gamesheet items covering the same objective. These revisions required primarily editing and rewriting of items in the worksheets and gamesheets, and were based mainly on specific item suggestions made by reviewers and teachers using the materials.

Activity 5: Disseminate the materials

Commerical publication was proposed as the most effective feasible way to disseminate the developed science materials. The project issued an RFP to publishers during the development of the materials, describing the project, providing sample materials, and asking publishers to indicate their intent. One publisher has indicated interest and is currently examining the full set of materials.

Appendix D contains the complete sets of TGT Life and Physical Science materials developed by the project.

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Appendix A

Life Science and Physical Science Learning Objectives

TGT Life Science Objectives

The TGT Life Science curriculum materials consist of forty seven sets of worksheets and gamesheets that cover specific learning objectives. These objectives are classified under seven basic units: The Structure of Matter, General Equipment, Life Processes, Genetics, Health, Ecology, and Careers.

I. The Structure of Matter
- I.1 - Vocabulary
  Students will define and match the definitions of terms associated with matter, and will classify various forms of matter.
- I.2 - Chemical Elements and Symbols
  Students will identify the names of common elements and their symbols.
- I.3 - Elements, Compounds and Mixtures
  Students will classify substances as elements, compounds, or mixtures.

II. General Equipment
- II.1 - Laboratory Equipment
  Students will identify equipment used in science experiments.
- II.2 - Compound Microscope
  Students will identify the structure and function of parts of a "typical" compound microscope.

III. Life Processes
- III.1 - Summary of Life Processes
  Students will identify the definitions associated with the activities of living things, and will identify life processes using real situations.
- III.2 - Cell Structure and Function
  Students will identify the parts and functions of a typical plant cell and animal cell, and compare a typical plant and animal cell.
- III.3 - Levels of Organization
  Students will identify tissues, organs, and systems of an organism.
- III.4 - Classifying Living Things
  - III.4.1 - Plant Classification
    Students will classify each plant given according to specific characteristics.
  - III.4.2 - Animal Classification
    - III.4.2.1 - Students will classify each animal organism according to specific characteristics.
    - III.4.2.2 - Students will identify each organism from its description.
- III.5 - Food Making
  - III.5.1 - Leaf Structure
    Students will identify the structures and function of a typical leaf.

III.5.2 - Photosynthesis
Students will identify the steps in the food making process, and will compare the light and dark phases of photosynthesis.

III.5.3 - Edible Plant Parts
Students will classify food or beverage sources as the edible parts of flowering plants.

III.6 - Digestion

III.6.1 - The Digestive System
Students will identify the organs of a typical drawing of the human digestive system and recognize their functions.

III.6.2 - Chemical Digestion
Students will identify (1) the types of nutrients present in a meal, (2) where each step of digestion takes place and the digestive juices that act upon proteins, fats, and carbohydrates, and (3) the end products of protein, fat and carbohydrate digestion and the ways in which they are carried to and absorbed by the body cells.

III.7 - Transport in Living Things

III.7.1 - Plant Transport
Students will identify the major function of each plant organ and the structure and function of the two main parts of a plant's transport system, and will compare vascular systems of a woody plant and an herb (herbaceous) plant.

III.7.2 - The Heart
Students will identify the parts of the heart and their function in the circulatory system, and will trace the circulation of blood by listing the parts of the heart in sequence.

III.7.3 - The Blood
Students will identify the parts of the blood and the function of each part, and various blood disorders from their descriptions.

III.8 - Breathing and Respiration

III.8.1 - Exchanging Gases
Students will match organisms with their method of exchanging oxygen and carbon dioxide.

III.8.2 - The Respiratory System
Students will identify the parts of the human respiratory system and the function of each part, and will distinguish between respiration and breathing.

III.9 - Waste Regulation and Excretion
Students will identify the structure and function of the organs associated with waste regulation and excretion, and will identify metabolic wastes and how organisms get rid of them.

III.10 - Control Systems

III.10.1 - Neurons and Reflexes
Students will identify the function and location of three types of neurons, and will distinguish between stimuli and responses.

III.10.2 - The Nervous System

Students will identify the parts and functions of the brain, distinguish between the parts and the functions of the central and peripheral nervous system, and identify diseases or disorders of the nervous system.

III.10.3 - Ductless Glands

Students will identify the location and function of ductless glands, and will identify the gland responsible for certain described conditions or situations.

III.10.4 - The Sense Organs

Students will identify the functions of the sense organs, and the structure and function of the eye and ear.

III.11 - Support and Movement

III.11.1 - Human Skeleton

Students will identify bones that protect vital organs, identify and give examples of major types of joints, and identify the structure and composition of bones.

III.11.2 - Muscles

Students will identify and compare the structure and function of three types of muscles, compare voluntary and involuntary muscles, identify muscles that bend and extend joints in the arm, and identify diseases or disorders associated with muscles.

III.12 - Reproduction

III.12.1 - Cell Division

Students will identify the major phases of mitosis, and will identify the major parts of a cell involved in cell division.

III.12.2 - Asexual Reproduction

Students will distinguish among five methods of asexual reproduction, and will identify organisms that reproduce asexually.

III.12.3 - Sexual Reproduction

III.12.3.1 - Plants

Students will identify the parts and function of each part of a flower, and will distinguish between pollination and fertilization.

III.12.3.2 - Vertebrates

a) Students will define terms or symbols associated with the sexual reproduction unit, and will match the vocabulary terms or symbols with their definitions or descriptions

b) Students will classify vertebrates according to the method by which the egg is fertilized, the embryo is developed, and the method by which vertebrates care for their young.

IV. Genetics

IV.1 - Genetics Vocabulary

Students will define terms associated with genetics, and will select the trait or method of breeding that fits each group of words.

IV.2 - Dominance and Recession

Students will identify and compare dominant traits and recessive traits which Mendel observed in pea plants, and will compute a problem showing the possible gene combinations from a cross between two organisms.

IV.3 - Incomplete Dominance

Students will interpret information and solve problems about incomplete dominance in organisms.

V. Health

V.1 - Nutrient Sources and Functions

Students will be able to (1) identify food sources of the major nutrients, (2) name deficiency diseases associated with vitamin deficiencies (A, B complex, D, K, C), (3) identify the functions of major nutrients, (4) name the Basic Four Food Groups, and (5) name foods contained in each of the Basic Four Food Groups.

V.2 - Diseases

V.2.1 - Infectious Diseases

Students will state the microorganisms that cause infectious diseases and the ways in which these diseases spread to humans.

V.2.2 - Noninfectious Diseases

Students will classify various types of noninfectious diseases.

VI. Ecology

VI.1 - Communities

VI.1.1 - Community Relationships

Students will define vocabulary terms associated with the relationships in a natural community and a natural ecosystem, identify and give examples of various relationships within a natural community and a natural ecosystem, and identify and give examples of various factors which control populations and communities in an ecosystem.

VI.1.2 - Biomes of North America

Students will identify the conditions and organisms which can be found in certain biomes.

VI.2 - Ecosystems

VI.2.1 - Food Webs

Students will define producers, consumers, decomposers, food chains and food webs, and will distinguish among first-order, second-order, and third-order consumers and producers.

VI.2.2 - Interactions in the Ecosystem

Students will identify harmful and/or helpful interactions in the ecosystem.

VI.3 - Recycling Matter

VI.3.1 - Identifying Elements of Cycles

Students will identify the cycle to which each process is most closely related.

VI.3.2 - Cycle Processes

Students will interpret information about the process involved in the water cycle, the carbon dioxide-oxygen cycle, and the nitrogen cycle.

VII. Careers in Life Science

VII.1 - Biology-Related Careers

Students will identify various biology-related careers from a brief description and/or the minimum training requirements.

VII.2 - Health Careers

Students will identify health occupations from a brief description and/or the minimum training requirements.

TGT Physical Science Objectives

The TGT Physical Science curriculum materials consist of forty-two sets of worksheets and gamesheets that cover specific learning objectives. These objectives are classified under six basic units: Chemistry; Work, Force, and Motion; Light and Sound; Heat Energy; Electricity, and Measurement.

I. Chemistry

I.1 - Laboratory Equipment

Students will identify equipment used in physical science experiments.

I.2 - Physical and Chemical Change

a. Students will identify a given change as a physical or chemical change.

b. Students will distinguish examples of either a physical or chemical change from among other given examples of changes.

I.3 - Solutions and Suspensions

a. The student will classify familiar mixtures as solutions or suspensions.

b. The student will identify the basic properties of a solution and a suspension.

I.4 - Element Symbols

Students will identify the names of common elements and their symbols.

I.5 - Acids, Bases and Salts

Students will classify a chemical substance as an acid, base or salt when given a formula or property of a substance.

I.6 - Elements, Compounds and Mixtures

Students will classify substances as elements, compounds, or mixtures.

I.7 - Common Elements, Radicals and Compounds

a. Students will identify common elements and radicals by their formulas or symbols.

b. Students will classify formulas and symbols as elements, radicals or compounds.

I.8 - Atomic Structure

I.8.1 - Periodic Table

Students will determine an element's name, symbol, atomic weight and atomic number using the periodic table.

I.8.2 - Atomic Structure

a. Students will apply a set of rules and use the periodic table to assist them in computing the number of electrons, protons and neutrons in an atom.

b. Students will arrange electrons in the K, L, and M electron shells for the first eighteen elements on the periodic table.

I.8.3 - Count the Atoms

Students will compute the number of atoms in a formula or equation.

I.9 - Properties and Purification of Water
Students will identify the properties of water and demonstrate basic knowledge of the water purification process.

I.10 - Bonding and Valence
a. Students will be able to determine the valence of common chemical elements.
b. Students will classify elements as metals, non-metals, or noble gases according to their valence.

I.11 - Making Chemical Formulas
Students will arrange elements and radicals to produce correct chemical formulas.

I.12 - Identify the Reaction
Students will identify reactions by examining their equations.

I.13 - Organic and Inorganic Formulas
a. Students will construct a simple molecular formula when given the structural formula.
b. Students will identify a given structural formula as being either organic or inorganic.

I.14 - Chemistry Vocabulary Review
Students will define chemistry unit terms.

II. Work, Force and Motion

II.1 - Simple Machines
a. Students will identify practical examples of levers.
b. Students will compute the IMA, AMA, and efficiency of a lever system by applying the formulas.

II.2 - Ideal Mechanical Advantage (IMA)
a. Students will compute the IMA of simple machines.
b. Students will match IMA formulas with the proper machine.
c. Students will identify factors that affect the IMA of a simple machine.

II.3 - Laws and Principles of Motion
Students will be able to apply Newton's laws of motion and Bernoulli's principle to practical events.

II.4 - Density
a. Students will define terms related to density.
b. Students will apply the density formula and find the density of regular and irregular shaped objects.

II.5 - Energy Conversions
Students will identify energy conversions that take place in common energy conversion systems.

II.6 - Work, Force and Motion Vocabulary Review
Students will define the basic vocabulary words used in the Work, Force and Motion unit.

II.7 - Parts of a Car
Students will identify the main parts of the car.

III. Light and Sound

III.1 - Light and Matter Relationships
Students will classify objects according to their relationship with light.

III.2 - Refraction and Reflection

a. Students will be able to identify types of mirrors.
b. Students will determine the path light will take as it passes through a transparent media.
c. Students will determine the path light will take as it is reflected by a mirror.

III.3 - The Eye

a. Students will identify the parts of the eye.
b. Students will identify the functions of the parts of the eye.
c. Students will recognize the differences between nearsightedness and farsightedness.

III.4 - Producing Color

a. Students will identify the color systems and their primaries.
b. Students will order and identify the colors of the spectrum.
c. Students will predict the results of mixing colors and color systems.

III.5 - Light Vocabulary

Students will define words necessary for understanding the nature of light.

III.6 - Waves and the Ear

a. Students will distinguish between waves and their parts.
b. Students will identify parts of the ear and their function.
c. Students will distinguish between frequency and pitch.

III.7 - Sound Vocabulary Review

Students will define the basic words needed to understand the relationship between waves and sound.

IV. Heat Energy

IV.1 - Heat Transfer

a. Students will identify and distinguish among the methods of heat transfer.
b. Students will define the terms insulator and conductor.
c. Students will identify substances that conduct and insulate against heat.

IV.2 - Heat and Temperature

a. Students will identify common Celsius and Fahrenheit temperatures.
b. Students will convert readings from one temperature scale to the other.
c. Students will compute heat energy loss and gain.

IV.3 - Heat Graphs

a. Students will be able to interpret latent heat factors from a graph.
b. Students will be able to identify latent heat points.

IV.4 - Heat Vocabulary Review

Students will define basic terms used in the study of heat energy.

V. Electricity

V.1 - What Charge and Why?

a. Students will define the terms "negative charge" and "positive charge."

b. Students will determine if an object is negatively or positively charged.

V.2 - Ohm's Law

a. Students will write and apply Ohm's Law.

b. Students will identify the units and symbols used to measure current, resistance, and electromotive force.

V.3 - General Circuits

a. Students will distinguish between a series and a parallel circuit.

b. Students will calculate the voltage and resistance in parallel and series circuits.

c. Students will identify an open or closed circuit.

V.4 - Electrical Symbols

Students will identify electrical symbols.

V.5 - Electronic Circuits

a. Students will identify the parts of a radio circuit.

b. Students will identify the function of each part of a radio circuit.

V.6 - Electricity Vocabulary Review

Students will be able to define words necessary for understanding electrical concepts.

VI. Measurement

VI.1 - The Metric System

a. Students will identify and use the basic units for measuring length, volume, area and mass in the metric system.

b. Students will compute the conversion of units within the metric system.

VI.2 - Scientific Notation

a. Students will express large numbers in a scientific notation form.

b. Students will convert scientific notation to regular numbers.

Appendix B

Evaluation Instruments and Instructions

Team Observation Checklist

General Teams Observation

1. Teams are microcosm of class. yes ___ no ___
2. Teams are primarily on task. yes ___ no ___
3. Noise level is tolerable. yes ___ no ___
4. Teacher moves from team to team. yes ___ no ___
5. Students are primarily peer-tutoring. yes ___ no ___

Specific Team Observation Team Name: _____

1. The team practice mode is...
   - four students interacting ___
   - three students interacting, one isolate ___
   - two-by-two interaction ___
2. Students are primarily on task. yes ___ no ___
3. Students are encouraging one another. yes ___ no ___
4. Students are having personality differences. yes ___ no ___
5. Students are learning items. yes ___ no ___
6. Students request teacher help. ___ ___ ___ ___ ___ ___

Comments:

_____

_____

_____

_____

_____

_____

_____

Tournament Observation Checklist

General Tournament Observation

1. Students understand game rules. yes ___ no ___
2. Noise level is tolerable. yes ___ no ___
3. Teacher moves through classroom. yes ___ no ___
4. Students are primarily on-task. yes ___ no ___
5. High tables finish too quickly. yes ___ no ___
6. Low tables show great difficulty. yes ___ no ___
7. Teacher spends most time at..... low tables ___
   average tables ___
   high tables ___
   about equal ___

Specific Tournament Observation

	I	II
Students understand game rules.	yes___ no___	yes ___ no ___
Students are primarily on-task.	yes___ no___	yes ___ no ___
Students understand scoring.	yes___ no___	yes ___ no ___
Students answer most items correctly.	yes___ no___	yes ___ no ___
Students answer few items correctly.	yes___ no___	yes ___ no ___
Competition is even.	yes___ no___	yes ___ no ___
Students need teacher help.	_ _ _ _ _ _	_ _ _ _ _ _

Comments:

Team Practice Item Observation Checklist

Date: _____ School: _____

Subject: _____ Time of class: _____

(Worksheet) (Gamesheet) No. _____

Item No.	EA	A	AD	TD	Item No.	EA	A	AD	TD
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
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—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—

EA - Item is quickly answered and understood by all students with no disagreement or discussion.

A - Item is answered and understood by all students, with some discussion.

AD - Item generates much discussion and disagreement, but resolves into agreement and understanding.

TD - Item generates much discussion and disagreement, no final understanding; teacher help required.

NSF/TGT Science Project: Interview Format

I. The tape recorder should be used during the entire interview session.

II. Teacher Discussion: This should be an open-ended "ventilation" by teachers which may continue during the entire interview. The interviewer's role is to listen, clarify, and explain or help to solve problems if necessary. The interviewer's basic role is that of "helper." Teachers should be encouraged to solve most problems on the spot; however, make it clear we will be of support for any problems that arise and are beyond immediate solution.

III. Specific criteria: If teachers do not refer to any of the points listed below during the open ended discussion, ask about and clarify the following possible concerns:

_____ Class discipline

_____ Pupil enthusiasm

_____ Material problems

_____ Teacher preparation time

_____ Integration of TGT science materials into their regular curriculum

_____ Mechanical problems (e.g., absenteeism, scoring procedures)

Name _____

School _____

Grade _____

This notebook contains a copy of all the worksheets and gamesheets that you have selected to use in your application of TGT. As you use the materials in your classroom, please critique them by writing directly on the worksheets and gamesheets in this notebook. Indicate any items that are unclear, too difficult, too easy, unrelated to the objective, and so on. Change item wording in any way you feel it should be changed.

Please be critical. We want to make these materials as accurate, clear, and relevant as they can possibly be.

Thank you.